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# An examination of critical determinants of carbon offsetting attitudes: the role of gender

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## ABSTRACT

Utilizing two studies, determinants of travelers' carbon offsetting attitudes and the role that gender plays in cognitive appraisal and attitude formation are examined by exploring the interactions between knowledge, credibility, and trust and their relative impacts on behavioral intentions. Findings suggest that objective knowledge, subjective knowledge, trust, and credibility impact attitudes in dramatically different degrees. Females are found to be higher in objective knowledge, credibility of climate science, and carbon offsetting attitudes, whereas males are found to be higher in subjective knowledge. Knowledge is found to be not only an imperfect predictor of carbon offsetting attitudes but can negatively influence attitudes through indirect effects on trust and perceived credibility. Furthermore, travelers who process information heuristically (primarily males) will have significantly different responses to stimuli than travelers who process information systematically (primarily females). Implications for message framing and possible interventions to increase participation levels in voluntary carbon offset programs are discussed.

## ARTICLE HISTORY

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## KEYWORDS

Carbon offsetting; knowledge; cognitive appraisal; credibility of climate science; trust in companies

## Introduction

Climate change has been considered a looming global crisis and a threat to the future of humanity for over a generation. In the three decades following the U.N. Framework Convention on Climate Change and the first "World Scientists' Warning to Humanity" (Kendall, 2000) carbon emissions from tourism have remained on an upward trajectory. (Lenzen et al., 2018) Tourism is viewed as a major contributor to climate change (Becken, 2004; Kim et al., 2019) and is receiving increasing attention as a "polluting" industry. Both scholars and environmental organizations have emphasized the importance of changing tourists' behaviors to be more environmentally friendly (Arana et al., 2013; Gössling & Scott, 2018). However, studies have shown that despite pro-environmental beliefs, tourists' actual behaviors suggest a lack of commitment (Juvan & Dolnicar, 2014; Weaver, 2007). Furthermore, gaps exist between tourists' beliefs and their attitudes and behaviors (Arana et al., 2013; Becken, 2004; Choi & Ritchie, 2014; Gössling et al., 2009; Gössling & Scott, 2018; Mair, 2011; Segerstedt & Grote, 2016).

Although the concept of voluntary carbon offsetting (VCO) has been criticized as a form of "buying forgiveness" (Mair, 2011), carbon sequestration has the potential to contribute

meaningfully to the tourism industry's objective of reduced net carbon emissions (Chazdon & Brancalion, 2019). A significant proportion of travelers express willingness to offset tourism carbon emissions (Scott et al., 2015) making VCO a potentially effective adjunct to other carbon reduction strategies.

A number of factors have been identified that contribute to low VCO participation rates, including tourists' knowledge about climate change and carbon offsetting (Cohen & Higham, 2011; Segerstedt & Grote, 2016), perceived credibility of climate science (Hartman et al., 2017), and trust in carbon offsetting programs and the companies that offer them (Dhanda & Hartman, 2011; Kim & Kim, 2014). Additional factors identified in the literature include assigning responsibility for resolving climate change issues to others (Gössling, 2009) or the sense that one person's effort will not make a difference (Gössling & Peeters, 2007). However, a factor that is largely missing from studies on sustainable attitudes is the influence of gender in the cognitive processing of environmental information. Although past research has addressed relationships between gender and environment from the perspectives of gender equity (Dankelman & Jansen, 2010) and pro-environmental attitudes (Economou & Halkos, 2020), few studies have considered methods of increasing VCO participation based upon the different cognitive processes of males and females, with largely insignificant or mixed findings (Dolnicar & Leisch, 2008; Juvan & Dolnicar, 2017). Missing from the literature are assessments of how environmental attitudes are influenced differently between genders and how the differences in cognitive processing of information between females and males might lead each gender to change their attitudes differently. This research gap is significant because, if indeed females and males have different psychological attributes and underlying mechanisms influencing their environmental attitudes, unlocking those differences may be the key to finally effecting changes in environmental behaviors.

This study will address the gap in previous research by investigating the moderating role of gender on tourists' attitudes toward addressing climate change (specifically, on attitudes related to offsetting tourism-related carbon emissions) and exploring how cognition and information processing affect attitudes and carbon offsetting decisions. More specifically, this study will examine how the cognitive appraisal process produces different environmental attitudes for females than males as a result of different levels of knowledge, trust in carbon offsetting companies and perceived credibility of climate science. The effects of interactions between those attributes and environmental attitudes will be explored to provide examine whether different information processing strategies influence attitudes in diverging ways. Findings of this study will contribute to the current knowledge by identifying whether gender plays a significant role in determining environmental attitudes and illustrating whether male and female attitudes toward carbon offsetting are affected by different stimuli. Implications for industry are made and gender-specific strategies for improving attitudes toward carbon offsetting are recommended.

## Literature review

### *Theoretical background*

The theoretical model of this study is built on Lazarus' (1991) cognitive appraisal theory (CAT), which suggests that an individual's response to a stimulus is determined by emotions generated through a two-stage cognitive appraisal process (Kuo & Wu, 2012). The primary stage involves quick evaluation about a stimulus based on pre-existing knowledge, whereas the secondary stage comprises more deliberate assessments which are strongly influenced by the primary appraisal (Kuo & Wu, 2012). As mental states evolve from psychological appraisals that are unique to each individual, people are likely to have disparate responses to the same situations depending on their past experiences (Choi & Choi, 2019) and the degree to which the situation conforms or conflicts with their personal beliefs (Cai et al., 2018). For an overview of CAT please see Roseman (1984) or Lazarus (1991).

Tourism scholars recognize that both tangible and intangible attributes influence tourists' appraisal of their travel experiences (Bagozzi et al., 1999; Choi & Choi, 2019), thus making CAT an appropriate theoretical framework. CAT has also been applied previously to studying environmental risk perceptions, recognizing that consumers process environmental risks with dual affective and cognitive approaches (Keller et al., 2012). CAT has also been utilized to explain behaviors for complex stimuli in hospitality research, including acceptance of artificial intelligence devices (Gursoy et al., 2019), residents' support toward events based upon their trust in government (Ouyang et al., 2017), and assessment of disruptive restaurant behavior (Cai et al., 2018).

### ***The role of gender on environmental attitudes***

The influence of gender on environmentalism has been studied for decades by sociologists (Dankelman & Jansen, 2010; McCright, 2010; Zelezny et al., 2000) and gender is widely considered an important determinant in attitudes toward the environment (McKercher et al., 2011) but it is still considered to have received little attention from scholars (Scannell & Gifford, 2013; Terry, 2009). Several theories have been introduced to explain gender differences in pro-environmental attitudes, including socialization theory, structural theory, value-belief-norm theory, social roles thesis, and the institutional trust hypothesis (Economou & Halkos, 2020; McKercher et al., 2011; Strapko et al., 2016). The result of this stream of research is a combination of robust patterns but inconclusive results that predominantly treat gender as a control variable in studies rather than a primary predictor of environmental attitudes (McCright, 2010).

Early studies identified largely consistent differences between genders in environmental attitudes but could not coalesce around meaningful interpretations of the underlying factors (Bord & O'Connor, 1997; Xiao & McCright, 2012). Females are generally shown to exhibit greater levels of environmental concern and to engage in more environmentally-oriented behavior (Zelezny et al., 2000). However, gender differences in environmental attitudes have been attributed by some researchers to perceived vulnerability and risk tolerance (Bord & O'Connor, 1997; Brody, 1984; Finucane et al., 2000) socioeconomic factors and political ideology (Davidson & Haan, 2012; Economou & Halkos, 2020; Finucane et al., 2000; McCright & Dunlap, 2011; Strapko et al., 2016), or have been found to be insignificant (Dietz et al., 2007; Heath & Gifford, 2006; Strapko et al., 2016; Whitmarsh & O'Neill, 2010). The preponderance of findings are that the environmental attitudes of males and females are significantly different (McKercher et al., 2011; Strapko et al., 2016; Xiao & McCright, 2012; Zelezny et al., 2000) but it is not clear what might be causing this significant difference. Studies argue that males and females are likely to process information differently (McCright, 2010; Scannell & Gifford, 2013), which can result in significant differences in the level of knowledge and the type of knowledge each gender value and retain, in their trust levels and their perception of the credibility, all of which can influence attitudes. Since it is not clear what might be causing these significant differences, it is important to investigate the cause of differences in male and female attitudes toward carbon offsetting.

### ***Psychological barriers to sustainability***

Tourists express concern for the environment (Gössling & Scott, 2018) but little interest in changing their travel behaviors (Cohen & Higham, 2011; Mair, 2011), prompting tourism researchers to explore psychological factors as barriers to sustainable behaviors. The role of personal variables such as attitudes, beliefs, norms and values have been documented in past research, but the conclusions regarding the influence of these variables on environmental behavior have not been consistent (Vicente-Molina et al., 2018).

### Knowledge

A number of studies have identified tourists' lack of knowledge about tourism's impact on climate change as an impediment to environmental behavior by tourists (Hares et al., 2010; Juvan & Dolnicar, 2017; White et al., 2019). Consumer knowledge has been found to have a strong impact on decision-making across a broad range of environmental behaviors (Milfont et al., 2012; O'Connor et al., 1999), although the relationship between knowledge and environmental behavior has been shown to be inconsistent (Juvan & Dolnicar, 2017; Marquart-Pyatt et al., 2011).

A significant gap has been identified in the carbon offsetting literature, with large numbers of tourists unaware of their carbon emission levels or VCO options. Although some research suggests that addressing the knowledge gap would help stimulate more pro-environmental behaviors (Becken, 2004; Choi & Ritchie, 2014; Gössling et al., 2009; Hares et al., 2010; Segerstedt & Grote, 2016), the link between knowledge and environmental behavior is not clear (Vicente-Molina et al., 2018). Some studies suggest that there is no significant link between knowledge and environmental behavior (Laroche et al., 2001) or that increased levels of knowledge actually correspond with reduced levels of concern for the environment (McCright, 2010) while others suggest that increasing the levels of knowledge by providing information can make tourists behave more environment friendly (Dolnicar, 2020). Because of these contradictory findings reported in previous studies about the role of knowledge and how knowledge is processed, thus, requires further exploration.

Studies of social cognition have revealed that different types of knowledge and different knowledge processing strategies have widely disparate influences over consumer behavior (Carlson et al., 2009; Ellen, 1994). Studies differentiate between objective knowledge (accurate information about a subject) and subjective knowledge (self-beliefs about one's relative level of knowledge) and have shown that each form of knowledge influences consumer behaviors independently (Carlson et al., 2009; Ellen, 1994). As an example, Malka et al. (2009) found complex interactions between subjective knowledge, credibility of climate science, and beliefs in global warming that suggest that the relationship between knowledge about global warming and concern for the planet is only significant for people who trust scientists (Malka et al., 2009; Milfont et al., 2012).

Researchers have also studied the impact of knowledge processing strategies on consumer behavior. The Heuristic and Systematic Processing Model is a widely-applied theory which identifies two distinct pathways employed to process information. Systematic processing is described as comprehensive and analytical, whereas heuristic processing is more inferential and relatively effortless (Hlee et al., 2018; Meyers-Levy & Maheswaran, 2004). Subjective information has been shown to be processed heuristically and is believed to have weaker persuasive power, whereas objective information is processed systematically and has been found to have more persuasibility (Chaiken et al., 1989). A person who has a higher-level of subjective knowledge may be due to the exposure of subjective information (e.g., other people's opinions regarding climate change). In contrast, a person who has a higher-level of objective knowledge is mainly caused by the processing of objective information (e.g., a precise number of how the level of carbon emission changed). Thus, each form of knowledge is hypothesized to have different impacts on consumer attitudes toward carbon offsetting.

Studies of the interactions between knowledge and trust and between knowledge and credibility of climate science reveal complex interrelationships (Denton et al., 2020). Malka et al. (2009) found that the association between subjective knowledge and concern over the environment was uniformly positive among people who trust scientists, but studies evaluating objective knowledge are limited. The interactions between both subjective and objective knowledge and both company trust and credibility of climate science are expected to be similarly complex, with the strongest correlations occurring between subjective knowledge - heuristic information processing and objective knowledge - systematic information processing.

It is hypothesized that interactions between knowledge type and information processing will result in differences in tourists' attitudes toward carbon offsetting. Tourists higher in objective knowledge who employ systematic information processing strategies are more likely to form opinions based upon scientific research and academic sources because they gather information comprehensively and employ more careful reasoning by virtue of their systematic processing. These tourists are expected to assess facts rather than relying upon opinions or conjecture, which would lead them to place greater credibility in climate science. Systematic information processors are also more likely to be aware of past "greenwashing" transgressions and other deceptive or irresponsible corporate behaviors and therefore be less inclined to place trust in carbon offset providers.

H1: Higher levels of objective knowledge will correspond with lower levels of trust in carbon offsetting companies

H2: Higher levels of objective knowledge will correspond with higher levels of credibility of climate science

Conversely, tourists who have higher levels of subjective knowledge are more likely to utilize heuristic information processing strategies because of their self-assessed prior knowledge (Meyers-Levy & Maheswaran, 1991). This processing strategy is more prone to superficial assessments, including reliance upon unsubstantiated claims, non-scientific opinions, and media sources that may have pro-corporate bias (Dietz et al., 2007; Meyers-Levy & Maheswaran, 2004). These heuristic information processors are hypothesized to be influenced to a greater degree by the opinions of others (including climate-deniers) as well as advertisements and company claims about environmentalism. This would lead heuristic processors to place greater trust in companies while also questioning the credibility of climate science due to the influence of climate deniers and other non-scientific opinion-makers.

H3: Higher levels of subjective knowledge will correspond with higher levels of trust in carbon offsetting companies

H4: Higher levels of subjective knowledge will correspond with lower levels of credibility of climate science

### *Gender differences in knowledge*

Despite a significant body of literature indicating that science and math education facilitates gender inequality in favor of males (McCright, 2010), Scannell and Gifford (2013) identified that women are more likely than men to gather information on global warming to make their assessments. Males indicate higher levels of self-assessed knowledge compared to females (Bord & O'Connor, 1997), but females actually possess higher levels of actual knowledge than males (McCright, 2010). The propensity for females to underestimate their knowledge (and for males to overestimate it) is indicative of gender differences in subjective and objective knowledge.

H5: Males and females have significantly different levels of subjective knowledge regarding climate change and carbon offsetting

H6: Males and females have significantly different levels of objective knowledge regarding climate change and carbon offsetting

### *Trust in company*

In this study, trust in company refers to trust in tourism operators who offer carbon-offsetting programs. Although greater knowledge is considered necessary to increasing VCO participation, knowledge by itself is not considered sufficient to engender needed changes (Milfont et al., 2012). Trust, or the accepting of vulnerability based upon positive expectations of the intentions or behavior of another (Rousseau et al., 1998), has also been shown to determine customers'

willingness to engage in sustainability (Ponnepureddy et al., 2017; Rahman et al., 2015). Trust involves consumers not just placing trust in a single actor but in an industry or group of actors (Doney & Cannon, 1997; Nunkoo & Gursoy, 2016), and trusting both their benevolence and their performance (Doney & Cannon, 1997; Lee et al., 2014). Trust between the stakeholders of a potential exchange has also been shown to influence decision-making outcomes (Blau, 1964; Ouyang et al., 2017), particularly in situations with high levels of uncertainty or incomplete knowledge (Dietz et al., 2007). Perceived untrustworthiness of companies has been shown to reduce customers' perception of control and lower their cooperation intentions (Seetanah & Sannasee, 2015). Trust is considered particularly salient to potential exchanges involving hospitality companies due to past instances of "greenwashing" (Ponnepureddy et al., 2017; Rahman et al., 2015) undermining trust in companies' motives for environmental initiatives.

H7: Trust in companies is positively correlated with attitudes toward carbon offsetting

### ***Gender differences in trust***

Studies have identified a strong correlation between company trust and risk perceptions, but also point to decisions to "trust the experts" often being made heuristically rather than systematically (Trumbo & McComas, 2003). Women have been found to be more critical of reported science and technology findings and, thus, less willing to accept the accuracy of those findings based on their face value compared to men (Jacobs & Simpkins, 2006; McCright, 2010). Women are more likely to form their opinions after systematic processing of the information while men are more likely to utilize heuristic processing and to make assessments based on a small number of heuristic cues. Thus, this study hypothesizes that there is a gender difference in levels of trust placed in carbon offsetting companies, with females placing lower levels of trust than males due to their reliance upon systematic information processing rather than heuristic assessments of company claims.

H8: Males and females have significantly different levels of trust in companies engaged in carbon offsetting

### ***Credibility of climate science***

Credibility of climate science affects how customers process information and their predisposition to act upon the information (Arora et al., 2006; Kim & Kim, 2014). Tourists considering engaging in carbon offsetting must also make an assessment of the overall credibility of the climate science relating to carbon emissions and potential global warming. Climate science is a controversial and heavily-debated topic (Gössling et al., 2015; McCright et al., 2013) and one where the consumers are compelled to rely upon the expertise of others due to the complexity and ambiguity of the information involved (Hartman et al., 2017). Compounding the issue for the past two decades have been disparate claims made by groups either espousing the risks of climate change or claiming the concerns are overblown, with each group espousing their own versions of scientific evidence (McCright et al., 2013).

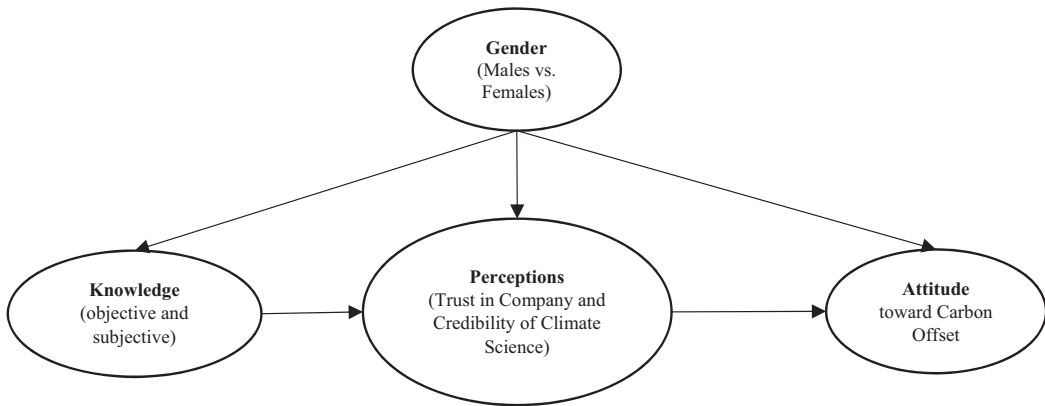
Identified gaps in the perceived credibility of climate science (Gössling et al., 2015; Kim & Kim, 2014) are particularly relevant in the context of tourists' disparate knowledge levels and information processing strategies – objective, systematic information processors are hypothesized to rely more upon scientific sources whereas subjective, heuristic information processors are more likely to be influenced by non-scientific opinion leaders.

H9: Credibility of climate science is positively correlated with attitudes toward carbon offsetting

### ***Gender differences in credibility of climate science***

Studies have established that women are more likely than men to believe in global warming (Bord & O'Connor, 1997; Joireman & Liu, 2014; Malka et al., 2009; McCright, 2010; Tranter, 2011),





**Figure 1.** Proposed conceptual model for cross-gender difference.

and that men are more likely to be climate deniers (Dunlap & McCright, 2011; Norgaard, 2011). Thus, this study hypothesizes that the differences in credibility of climate science are at least partially attributed to gender differences in information collection and processing. The well-established disjuncture between the views expressed by members of the national policy elite and the scientific consensus (Dietz et al., 2007; McCright & Dunlap, 2000) will lead to different outcomes for systematic versus heuristic information processors.

H10: Males and females have significantly different levels of credibility of climate science

### ***Gender differences in attitudes toward carbon offsetting***

Although few studies have compared attitudes toward carbon offsetting based upon gender, a significant body of literature has established that females have more environmental concern than men (Gifford et al., 1982) and are more likely to engage in behaviors to mitigate global warming (Bord & O'Connor, 1997; Dietz et al., 2007; Meier & Christen, 2012; O'Connor et al., 1999; Park & Vedlitz, 2013) and support climate change mitigation policies (Maibach et al., 2011; McCright et al., 2013). Thus, this study hypothesizes that the gender gap in attitudes toward carbon offsetting will mirror those of other environmental issues, which would be consistent with the cognitive appraisal process and the other hypotheses contained herein.

H11: Males and females have significantly different overall attitudes toward carbon offsetting

Based on the preceding discussion, the proposed conceptual model presented in Figure 1 is developed. The model suggests that individuals' level of objective and subjective knowledge is critical determinants of their trust in companies and their perceptions of credibility of climate science, which in turn influence their attitudes toward carbon offsetting.

## **Study 1: Examining the proposed conceptual model**

### ***Methodology***

#### ***Data collection***

The purpose of Study 1 was to validate the proposed cognitive appraisal model. First, 93 college students (47 female, 46 male) from a university located in North America were recruited to take part in the pilot study. The students were first asked to read descriptions of various carbon offsetting programs, and were then asked to answer a number of survey questions. Once they had completed the survey questions, they were asked to rate how clear the item was to ensure the survey was comprehensible. After refining the questionnaire based on the results the pilot study,



Study 1 recruited a customer panel via Amazon Mechanical Turk (Mturk). These customers (231 females, 231 males) were all from the United States. Participants who completed the survey and passed the attention checks received a small amount of monetary incentive (\$0.50).

### **Measurement instruments**

As presented in [Appendix A](#), *subjective knowledge* was measured by a three-item scale developed by Ellen (1994). Three items that were adopted from studies by Lang and Hallman (2005) were used to measure *trust in company*. *Perceived credibility of climate science* was measured by six items that were adopted from Hartman et al. (2017). *Attitudes toward carbon offsetting* were measured using the four-item scale developed by Hsu and Huang. ([Appendix A](#)). All items were measured on a 5-point Likert scale. Respondents' *objective knowledge toward carbon offsetting* was measured utilizing an eight-question quiz, following the approach used in previous studies (Huy Tuu et al., 2011; Pieniak et al., 2010). This method was used by several previous studies and is believed to be able to accurately measure objective knowledge (Huy Tuu et al., 2011; Pieniak et al., 2010). The quiz score was standardized for the data analysis and the reliability was fixed at eighty-five percent to assume fifteen percent of residual variance in objective knowledge (Huy Tuu et al., 2011; Jöreskog & Sörbom, 1996).

## **Results**

### **Pilot study**

In the pilot study, a confirmatory factor analysis was performed to validate the properties of the measurement instrument. In this analysis, common method bias, factor loadings, Cronbach's Alphas, convergent validities, and discriminant validities were examined. In addition, the score of understandability for each measurement item was evaluated. Based on these results, the measurement instruments were refined. Results of the pilot study indicated that all the items were understandable and had desired measurement property. Based on these results, all the survey items retained.

### **Main study**

In the main study, the demographic profile ([Appendix B](#)) of respondents was examined, and the data normality was investigated. A confirmatory factor analysis was then performed to validate the measurement model. Finally, the validity of the structural model was assessed through a covariance-based structural equation modeling (CB-SEM) with a maximum likelihood estimation. CB-SEM aims to estimate the difference between the observed covariance matrix and the estimated covariance matrix based on the theoretical model by providing useful model fit indexes (Hair et al., 2011). Furthermore, compared to other SEM approaches, the CB-SEM is considered to be more appropriate for model testing (Hair et al., 2017) ([Table 1](#)).

Before conducting the CFA analysis, researchers examined the distribution of the dataset for skewness and kurtosis. Afterwards, a Harman's single-factor test was conducted by loading all items into a single exploratory factor. Results of the Harman's single-factor test indicated that 41.05% of the total variance was explained by a single factor, suggesting that common method bias was not an issue. The results of CFA ([Table 2](#)) demonstrated that factor loadings of measurement items were all greater than 0.60, factors' Cronbach's Alphas were all greater than 0.80, and AVEs were all higher than 0.50. In addition, the factors' squared roots AVEs were all greater than their associated factor correlations ([Table 3](#)). These provided satisfactory evidence for the reliability and both convergent and discriminant validities of the measurement scale. Furthermore, model fit indices ( $\chi^2 = 199.30$ ,  $df = 110$ ,  $\chi^2$  to  $df$  ratio = 1.91, CFI = 0.99, TLI = 0.98, RMSEA = 0.04, SRMR = 0.03) point to a well-fitted measurement model.

Table 1. Demographic profile.

Demographic distribution % (n = 462)	
<b>Age</b>	
18-25	14.7
26-34	31.2
35-44	22.9
44-54	15.1
55-64	12.1
65 or over	3.9
<b>Marital Status</b>	
Single	37.2
Married	45.6
Live together	8.1
Divorced	0.7
Widowed	8.5
<b>Occupation</b>	
Student	6.7
Professional	49.4
Managerial	14.1
Sales	9.5
Homemaker	7.4
Other	13.0
<b>Education</b>	
Less than high school	0.7
High school graduate	6.9
College Degree	75.7
Professional degree	14.3
Doctorate degree	2.3
<b>Annual Income</b>	
Under \$10,000	5.8
\$10,000-\$29,999	18.0
\$30,000-\$49,999	22.3
\$50,000-\$69,999	22.1
\$70,000 – \$99,999	15.6
\$100,000 and above	16.2

Table 2. Measurement scale properties.

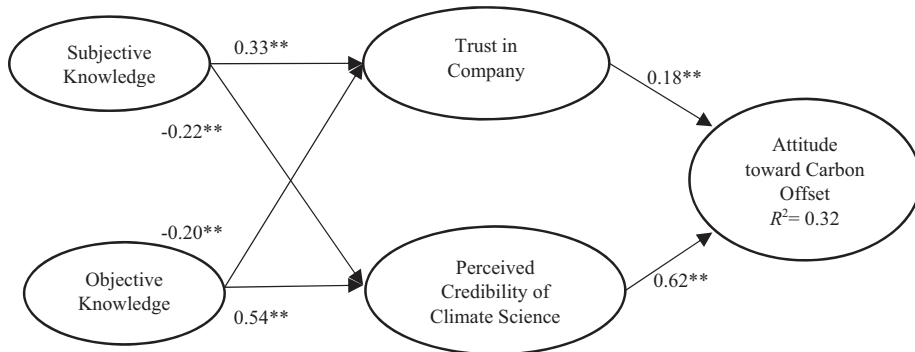
Constructs/items	Item loadings	Cronbach's alphas	AVE
<b>Subjective Knowledge (SK)</b>		0.89	0.74
SK1	0.88		
SK2	0.84		
SK3	0.86		
<b>Trust in Company (TC)</b>		0.89	0.72
TC1	0.84		
TC2	0.85		
TC3	0.86		
<b>Credibility (CR)</b>		0.96	0.79
CR1	0.91		
CR2	0.86		
CR3	0.88		
CR4	0.92		
CR5	0.89		
CR6	0.86		
<b>Attitude (A)</b>		0.93	0.78
A1	0.93		
A2	0.86		
A3	0.89		
A4	0.85		
<b>Objective Knowledge (OK)</b>		0.85	0.85
OK1	0.92		

Notes:  $\chi^2 = 199.30$ ,  $df = 110$ , CFI = 0.99, TLI = 0.98, RMSEA = 0.04, SRMR = 0.03.

**Table 3.** Correlations between Factor and Square Root of AVEs.

Factors	SK	TC	CR	A	OK
<b>Subjective Knowledge (SK)</b>	(0.860)				
<b>Trust in company (TC)</b>	<b>0.282</b>	(0.849)			
<b>Credibility (CR)</b>	<b>-0.115</b>	<b>-0.423</b>	(0.889)		
<b>Attitude toward carbon offset (A)</b>	<b>-0.174</b>	<b>-0.093</b>	<b>0.535</b>	(0.883)	
<b>Objective knowledge (OK)</b>	<b>0.218</b>	<b>-0.140</b>	<b>0.476</b>	<b>0.544</b>	(0.922)

Notes: Numbers in parentheses are square roots of AVE; Correlations in bold are significant at  $p < 0.5$  level.

**Figure 2.** Results of structural equation modeling analysis.

Notes:

Model-fit:  $\chi^2 = 261.27$ ,  $df = 112$ , CFI = 0.98, TLI = 0.97, RMSEA = 0.05, SRMR = 0.06.

\*\*: significant at the 0.05 level

The results of SEM analysis (Figure 2) revealed a well-fitted structural model ( $\chi^2 = 261.27$ ,  $df = 112$ ,  $\chi^2$  to  $df$  ratio = 2.33, CFI = 0.98, TLI = 0.97, RMSEA = 0.05, SRMR = 0.06), suggesting that the proposed cognitive appraisal model can explain a significant proportion of attitudes toward carbon offsetting ( $R^2 = .32$ ,  $p < .001$ ). Furthermore, the results indicated that objective knowledge negatively predicts trust ( $\beta = -.20$ ,  $p < .001$ ) and positively predicts credibility of climate science ( $\beta = .54$ ,  $p < .001$ ). Thus, H1 and H2 were supported. Conversely, subjective knowledge positively predicts trust ( $\beta = .33$ ,  $p < .001$ ) and negatively predicts credibility of climate science ( $\beta = -.22$ ,  $p < .001$ ). Therefore, H3 and H4 were supported. In addition, the results suggested that both trust ( $\beta = .18$ ,  $p < .001$ ) and credibility ( $\beta = .62$ ,  $p < .001$ ) have a significant impact on attitude, supporting H7 and H9.

### Discussion of study 1 findings

Study 1 confirms that subjective and objective knowledge have significant but contradictory impacts on attitudes toward carbon offsetting, and further validates the different roles of trust and credibility in the cognitive appraisal process. Trust has a positive mediation effect on the relationship between subjective knowledge and attitudes, whereby the attitudes of tourists with high subjective knowledge are enhanced by the higher levels of trust that they place in carbon offsetting companies, but lower levels of credibility of climate science more than offset the effect of trust, resulting in lower overall attitudes toward carbon offsetting as levels of subjective knowledge increase. For tourists high in objective knowledge the effects are significantly different, with reduced levels of company trust being more than offset by increasing credibility of climate science, resulting in overall higher attitudes toward carbon offsetting.

The reported split-group effect between subjective knowledge and objective knowledge is a significant finding. By better understanding the effects of knowledge and information processing

strategies, researchers and industry practitioners can devise messaging strategies (e.g., messages with different levels of objective or subjective information) to more effectively influence attitudes and avoid messaging that inadvertently lowers attitudes through unintended conditional interactions.

## Study 2: Exploring gender differences

### Methodology

Study 2 replicated the methodology of Study 1 by presenting questions to a panel of respondents recruited from Amazon MTurk in order to assess male and female respondents' objective knowledge, subjective knowledge, trust, credibility of climate science, and attitude. Objective knowledge about carbon emissions was measured in Study 2 using nine questions that were taken from the U.S. Department of Energy Climate IQ Quiz (<https://www.energy.gov/articles/quiz-test-your-climate-change-iq>). A tenth question was dropped from the IQ Quiz because it was pertained to per capita carbon emission levels between U.S. states and was considered unrelated to the research topic. A series of independent sample t-tests was performed to investigate whether there were any significant differences in objective knowledge, subjective knowledge, trust, credibility of climate science, and attitude between male and female respondents.

### Results

Four hundred and ninety participants took part in Study 2 (245 female, 245 male) by completing the survey and passing attention checks. The demographic statistics (Appendix B) suggest there was no significant deviation in terms of age, marital status, occupation, education, and family income between genders. Similar to the approach used in Study 1, data normality, measurement model properties including factor loadings, AVEs and Cronbach's Alphas, and overall measurement model fit ( $\chi^2 = 162.33$ ,  $df = 110$ ,  $\chi^2$  to  $df$  ratio = 1.48, CFI = 0.99, TLI = 0.98, RMSEA = 0.03, SRMR = 0.03) were examined to ensure the reliability of the data. All of the model fit indicators suggested that the measurement model was appropriate.

### T-tests

The results of t-tests (Table 4, Figure 3) demonstrated statistically significant differences in factor mean scores across gender groups. Study 2 found that the factor mean of subjective knowledge was higher for males ( $\bar{x}_m = 3.47$ ,  $\bar{x}_f = 3.24$ ,  $t = 2.89$ ,  $p = .004$ ) while the factor mean of objective knowledge was significantly higher for females ( $\bar{x}_f = 2.90$ ,  $\bar{x}_m = 2.71$ ,  $t = -2.68$ ,  $p = .008$ ). Females also achieved significantly higher scores in perceived credibility of climate science ( $\bar{x}_f = 3.52$ ,  $\bar{x}_m = 3.21$ ,  $t = -2.94$ ,  $p = .003$ ), and attitudes toward carbon offsetting ( $\bar{x}_f = 3.94$ ,  $\bar{x}_m = 3.59$ ,  $t = -4.61$ ,  $p < .001$ ). Therefore, support was provided for hypotheses H5, H6, H10, and H11. Interestingly, no significant main effect of gender was found on trust ( $\bar{x}_f = 3.22$ ,  $\bar{x}_m = 3.16$ ,  $t = -0.65$ ,  $p = .52$ ), thus failing to support hypothesis H8. These findings were confirmed by tests of the pilot study and Study 1 datasets, which resulted in findings that were consistent using different samples and different measures of objective knowledge.

The non-significant findings of the main effect in trust across gender was unexpected. To further explore the differences in trust across genders, this study examined the moderation effect of gender in the relationship between trust, credibility and attitude using floodlight analysis.

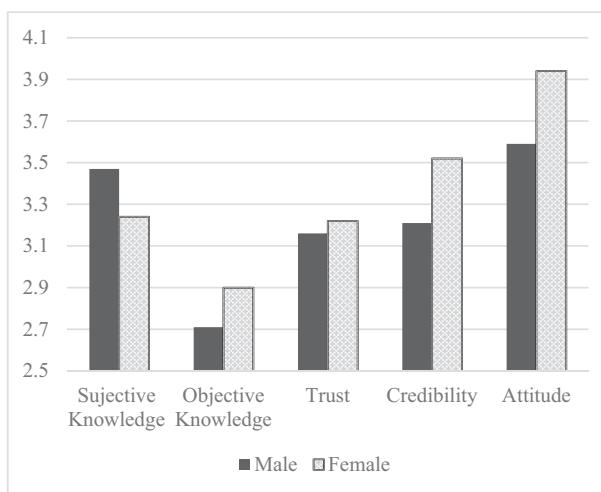
**Table 4.** Results of Independent Samples T-tests.

Factors	Pilot Study (n = 93) Student Sample				Study 1 (n = 462) Online Sample				Study 2 (n = 490) Online Sample				Hypothesis
	$\bar{x}$ male	$\bar{x}$ female	<i>t</i>	<i>p</i>	$\bar{x}$ male	$\bar{x}$ female	<i>t</i>	<i>p</i>	$\bar{x}$ male	$\bar{x}$ female	<i>t</i>	<i>p</i>	
SK	3.36	2.94	2.07	.04**	3.20	3.02	1.77	.08*	3.47	3.24	2.89	.004**	H7
OK	3.20	3.56	-2.64	.01**	3.70	3.97	-3.96	<.001**	2.71	2.90	-2.68	.008**	H8
TC	2.40	2.66	-1.58	.12	2.67	2.65	0.27	.79	3.16	3.22	-0.65	.52	H9
CR	2.67	3.01	-2.29	.03**	3.25	3.63	-3.30	.001**	3.21	3.52	-2.94	.003**	H10
A	3.74	4.11	-2.05	.04**	3.78	4.05	-2.94	.003**	3.59	3.94	-4.61	<.001**	H11

Notes:.

1. Objective Knowledge (OK), Subjective Knowledge (SK), Trust in Company (TC), Perceived Credibility of Climate Science (CR), Attitude toward carbon offset (A).

2. Objective knowledge was tested using two different quiz across study 1 and 2.

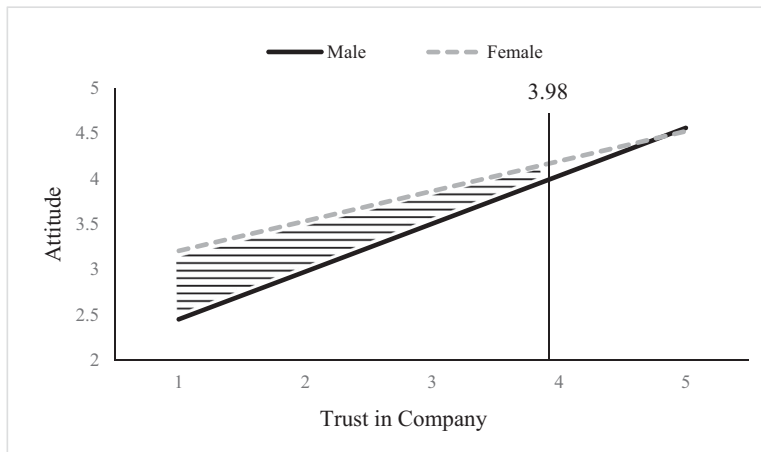
3. \*: *t* statistic is significant at the 0.1 level.4. \*\*: *t* statistic is significant at the 0.05 level.**Figure 3.** Mean differences across genders. PLEASE CORRECT SPELLING OF 'SUBJECTIVE' IN FIGURE 3...THE PROGRAM DOES NOT ALLOW ME TO EDIT THE FIGURE.....

### Moderation test

The results (Figure 4) of the moderation analyses provided evidence of an interaction between gender and trust and the outcome variable of attitude such that the influence of trust on attitudes was lower for females at lower levels of trust ( $b = -0.20$ ,  $p = .005$ , 95% CI (-0.33 to -0.06)). This creates a suppression effect between trust and attitude for females which was statistically significant when trust scores were less than or equal to 3.98. Among respondents with low levels of initial trust, an increased level of trust predicted significantly greater increases in attitudes for males than for females, whereas the effect of increases in trust was not different for males and females with high levels of initial trust.

### Indirect effect

To further examine the moderating effects of gender differences, this study conducted an indirect effect test using 10,000 bootstrapped samples (Hayes, 2018). The results indicated that there was a significant negative indirect effect of gender on attitude through subjective knowledge and trust (Gender  $\rightarrow$  SK  $\rightarrow$  TC  $\rightarrow$  A; 95% CI (-0.037 to -0.005)) and a significant positive indirect effect of gender on attitude through objective knowledge and credibility (Gender  $\rightarrow$  OK  $\rightarrow$  CR  $\rightarrow$  A; 95% CI (0.001 to 0.015)). This indicates that female attitudes may be increased by the



**Figure 4.** Results of floodlight analysis.

Note. Gender difference is significant ( $p < .05$ ) within the shaded (Johnson-Neyman) regions.

pathway from objective knowledge to perceived credibility of climate science whereas male attitudes are decreased indirectly via the negative influence of subjective knowledge on trust.

### Gender differences in environmental attitudes

Study two provides strong evidence of gender differences not only in environmental attitudes but in the psychological attributes that contribute to the formulation of environmental attitudes. Females show higher levels of objective knowledge, which is consistent with systematic information processing. Objective knowledge is associated with higher levels of credibility of climate science and lower levels of trust in carbon offsetting companies, which may be attributed to more comprehensive information gathering and reliance upon more scientific information sources. By contrast, males show higher levels of subjective knowledge which is consistent with heuristic information processing. Subjective knowledge predicts higher levels of trust in carbon offsetting companies but lower levels of perceived credibility of climate science.

Tracing knowledge levels through the cognitive appraisal model presented in Study 1 shows that an increased level of objective knowledge corresponds with increases in attitudes toward carbon offsetting, although the increases are dampened by the negative indirect effect of reduced trust. Conversely, an increased level of subjective knowledge corresponds with lower levels of attitude toward carbon offsetting as a result of the negative indirect effect of lower perceived credibility of climate science overshadowing the positive impact of higher trust.

### General discussion

This study contributes to the literature by supporting assertions that gender should be treated as an explanatory variable of environmental attitudes rather than a control variable (McKercher et al., 2011; Zelezny et al., 2000). This is one of the first studies that reveals that the interactions between subjective knowledge and objective knowledge are complex and are different between males and females. Findings further suggest an interaction effect between subjective and objective knowledge on individuals' attitudes towards carbon offsetting. However, the interactions between knowledge are mediated by trust in carbon offsetting companies and credibility of climate science, with opposing consequences on attitudes toward carbon offsetting. Subjective knowledge is shown to have a positive influence on trust but a negative influence on credibility

of climate science, suggesting that people who consider themselves to be knowledgeable about the environment are more likely to employ superficial heuristic information processing strategies which leads them to rely upon non-scientific information, opinions, and company appeals. This lower perceived credibility of climate science has a stronger negative impact on attitudes that more than offsets the positive impacts from increased knowledge and trust, suggesting that measures intended to increase knowledge may have a suppressing effect on attitudes toward carbon offsetting.

Conversely, those who are high in objective knowledge and employ systematic information processing strategies show a positive correlation between knowledge and credibility of climate science but a negative impact on trust in carbon offsetting companies. This suggests that tourists who employ comprehensive systematic information processing will rely more upon scientific information sources that increase their attitudes toward climate science but also act to lower their trust in the companies providing carbon offsetting. The negative indirect effect of objective knowledge on attitudes through trust partially attenuates but does not outweigh the combined positive direct effect of knowledge on attitudes and the indirect effect through credibility of climate science.

This study evaluates the role that gender plays in influencing tourists' attitudes toward carbon offsetting as a result of different cognitive processing, building upon the existing body of literature addressing gender-specific roles in environmental management (Dankelman & Jansen, 2010). This study shows that males are higher in subjective knowledge whereas females are higher in objective knowledge, credibility, and attitudes toward carbon offsetting. This finding suggests that females are significantly more likely to follow systematic information processing strategies whereas males are more likely to form attitudes using heuristic information processing. This suggests that a single strategy for modifying consumer behaviors may have positive effects on one gender but negative effects on the other through the diverging impacts of knowledge on attitudes through the prior influence of knowledge on trust and credibility.

Support is provided by this study for a moderating influence of gender on trust. Among respondents with low levels of initial trust, increases in trust predicted significantly greater increases in attitudes of males than of females, whereas the effect of increases in trust was not different for males and females with high levels of initial trust. These findings suggest that trust in company exhibits different influences on attitude across different genders. These results further suggest that increasing trust levels, especially increasing trust level of males, can have a magnifying effect on the impact of knowledge on attitudes toward carbon offsetting. This finding is especially important for enhancing the effect of objective knowledge on attitudes since low trust level was found to dampen the effects of objective knowledge.

The findings of this study have several implications for creating environmental appeals to change tourist behaviors. Understanding the factors that contribute to environmental attitudes is essential before policymakers can design and apply policies intended to change behaviors (Economou & Halkos, 2020). To that end, understanding how cognitive appraisals differ based upon knowledge and gender will help practitioners frame messages so as to achieve desired outcomes and avoid unintended consequences.

Appeals that focus on subjective knowledge would likely be more effective for males than for females due to the congruence with males' heuristic information processing strategies. These appeals could employ opinion leaders and superficial or limited hard information and should focus on presenting carbon offsetting companies as trustworthy to benefit from the positive correlation between subjective knowledge and company trust. These appeals would minimize scientific discussion due to the negative correlation between subjective knowledge and credibility of climate science.

Appeals that focus on objective knowledge would likely be more effective for females employing systematic information processing strategies. These appeals could include more facts and data; however, recognizing the inverse relationship between objective knowledge and



company trust, these appeals should de-emphasize the carbon offsetting companies and focus the tourists' attention on data and science.

## Conclusion, limitations and future directions

This study investigates determinants of tourists' carbon offsetting attitudes and the role that gender plays in cognitive appraisal and attitude formation. Results suggest that objective knowledge, subjective knowledge, trust, and credibility impact attitudes in dramatically different degrees. Females are found to be higher in objective knowledge, credibility of climate science, and carbon offsetting attitudes, whereas males are found to be higher in subjective knowledge. Knowledge by itself is found to be not only insufficient in predicting carbon offsetting attitudes but can actually reduce attitudes through indirect effects on trust and perceived credibility.

Although this study attempted to improve validity of the findings by employing multiple independent samples, it is not free of limitations. Relying on survey data limits the generalizability of the findings and precludes conclusions of causality. Experimental studies should be conducted under controlled conditions to evaluate the impact of these, and other, psychological attributes on tourists' carbon offsetting attitudes. Furthermore, studies that test the impact of knowledge manipulations on actual carbon offsetting behaviors would provide valuable additional insights.

This study confirms that the relationships between psychological attributes are complex and that cognitive appraisals differ for females and males, but much work remains to be done to identify additional variables and interactions between those variables, and to evaluate how those variables and interactions differ between males and females. A number of scientific fields and theories each contribute hypotheses regarding the causes of gender differences, including evolutionary psychology (Buss & Schmitt, 1993), sociocultural theory (Eagly & Wood, 1999) gender schema/cognitive social theory (Bussey & Bandura, 1999; Hyde, 2014), and biology (Penn, 2003); however, methods of applying these theories to produce tangible change in environmental attitudes and behaviors remains to be fully explored.

To the extent that cognitive appraisal contributes to the formulation of attitudes, it also needs to be explored whether these disparate information processing strategies can be effectively stimulated through message framing and "nudging" (Thaler & Sunstein, 2008; Tversky & Kahneman, 1981). This study suggests that environmental appeal messages that are effective with heuristic males may be counterproductive with systematic females by triggering reductions in trust of carbon offsetting companies, whereas messages that are effective for females might reduce attitudes among males through reduced credibility of climate science – these and other complex interactions should be substantiated by more in-depth experiments.

It also should be noted that this study focuses on explicit attitudes as self-reported by respondents. An interesting field of research developing over recent years explores the divergence between explicit and implicit attitudes and the potential for greater predictability of behaviors through assessments of implicit attitudes (see Beattie & McGuire, 2020). Furthermore, the potential exists for conditional interactions between explicit and implicit attitudes, with compounding effects when the two attitudes are in alignment and suppressing effects when they diverge. Although this topic is beyond the scope of this study, a much more robust understanding of the attitude-behavior gap may be possible through studies that jointly assess explicit and implicit attitudes.

Lastly, this study aims to investigate the cross-gender differences for general U.S. tourists, and respondents showed disproportionately high education levels. Therefore, the observations and conclusions from this study may not generalize to other cultures or samples with different education backgrounds. Additional studies should be conducted to determine whether information

processing mechanisms operate similarly among different sample groups across cultural and socioeconomic factors.

## Disclosure statement

No potential conflict of interest was reported by the authors.

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## Appendix A. Measurement items and properties

		Mean	SD	Skewness	Kurtosis
Item No.	Item Description	Study 1/ Study 2	Study 1/ Study 2	Study 1/ Study 2	Study 1/ Study 2
Subjective Knowledge (Ellen, 1994)					
SK1	I consider myself to be knowledgeable about the impact of travel on the environment	3.12/ 3.61	1.20/ 0.93	−0.15/ −0.63	−0.98/ −0.19
SK2	Compared to other people, I know a lot about the impact of travel on the environment	3.00/ 3.28	1.21/ 0.98	0.01/ −0.18	−0.97/ −0.51
SK3	People who know me consider me to be knowledgeable about the impact of travel on the environment	2.97/ 3.18	1.26/ 1.04	0.04/ −0.04	−1.04/ −0.70
Trust in Company (Lang & Hallman, 2005; Nunkoo et al., 2012)					
TC1	You can generally trust decisions regarding carbon offset made by tourism companies	2.71/ 3.28	1.05/ 0.97	0.16/ −0.42	−0.62/ −0.06
TC2	You can generally trust the people who run tourism companies to do what is right regarding carbon offset	2.66/ 3.30	1.06/ 1.04	0.15/ −0.33	−0.65/ −0.25
TC3	Tourism companies can be trusted to do what is right regarding carbon offset without our having to constantly check on them	2.58/ 3.00	1.14/ 1.09	0.33/ −0.06	−0.67/ −0.61
Credibility of Climate Science (Hartman et al., 2017)					
CR1	*People trust climate scientists a lot more than they should	3.56/ 3.25	1.35/ 1.29	−0.44/ −0.22	−1.12/ −1.06
CR2	*People don't realize just how flawed a lot of climate science research really is	3.56/ 3.27	1.30/ 1.30	−0.42/ −0.23	−1.03/ −1.08
CR3	*A lot of climate science theories and predictions are dead wrong	3.71/ 3.42	1.31/ 1.26	−0.54/ −0.32	−1.03/ −1.02
CR4	*Sometimes I think we put too much faith in climate science	3.68/ 3.40	1.37/ 1.34	−0.63/ −0.32	−0.97/ −1.17
CR5	*Our society places too much emphasis on climate science	3.67/ 3.48	1.38/ 1.33	−0.55/ −0.40	−1.12/ −1.07
CR6	*I am concerned by the amount of influence that climate scientists have in society	3.63/ 3.39	1.26/ 1.33	−0.42/ −0.28	−1.11/ −1.17
Attitude (Hsu & Huang, 2012)					
A1	I like the idea of offsetting carbon emissions when I travel	4.10/ 3.76	1.04/ 0.94	−1.18/ −0.84	0.98/ 0.77
A2	I have a favorable attitude toward offsetting carbon emissions	4.09/ 3.82	1.05/ 0.91	−1.19/ −0.94	1.01/ 1.14
A3	Offsetting carbon emissions when I travel would be worthwhile	4.06/ 3.72	1.04/ 0.98	−1.20/ −0.81	1.18/ 0.54
A4	Offsetting carbon emissions when I travel would be rewarding	3.97/ 3.68	1.03/ 1.00	−0.91/ −0.71	0.37/ 0.45
Objective Knowledge					
OK	Total score of a 8-question quiz (Study 1) and a 9-question quiz (Study 2)	3.21/ 3.84	0.72/ 0.76	−0.20/ −0.87	0.19/ 0.77

## Appendix B. Demographic profile across genders

		Study 1		Study 2	
		Male (n = 231)	Female (n = 231)	Male (n = 245)	Female (n = 245)
Age	18-25	13.4	16.0	15.9	17.1
	26-34	32.5	29.9	34.3	29.0
	35-44	22.5	23.4	25.7	28.2
	44-54	17.3	13.0	14.7	13.5
	55-64	10.8	13.4	6.9	9.4
	65 or over	3.5	4.3	2.4	2.9
Marital Status	Single	42.4	32.0	41.2	31.4
	Married	45.0	46.3	49.8	49.8
	Live together	7.4	8.7	5.3	11.8
	Divorced	0.4	0.9	2.9	5.7
	Widowed	4.8	12.1	0.8	1.2
Occupation	Student	7.4	6.0	9.4	11.4
	Professional	51.1	47.6	50.6	35.1
	Managerial	16.0	12.1	16.7	8.6
	Sales	10.4	8.7	5.3	7.3
	Homemaker	0.9	13.9	2.0	14.7
	Other	14.3	11.7	15.9	22.9
Education	Less than high school	0.9	0.4	0.0	1.2
	High school graduate	8.7	5.2	11.4	7.8
	College Degree	74.9	76.6	82.0	86.0
	Professional degree	12.5	16.0	2.9	3.4
	Doctorate degree	3.0	1.7	3.7	1.6
Annual Income	Under \$10,000	6.1	5.6	14.9	21.5
	\$10,000-\$29,999	16.9	19.1	13.9	19.2
	\$30,000-\$49,999	22.5	22.1	19.9	17.1
	\$50,000-\$69,999	23.4	20.8	29.7	20.4
	\$70,000 – \$99,999	15.6	15.6	8.2	10.6
	\$100,000 and above	15.6	16.9	13.5	11.2

## Appendix C. Quiz questions for examining objective knowledge

### Study 1

Please indicate whether you believe the following statements to be true or false (*true, false, or don't know*) regarding the impact of travel on the environment and carbon emissions generated by travel.

- Levels of carbon in the atmosphere are higher than what is considered sustainable.  
(Correct answer: True)
- Tourism is considered to be a significant contributor to carbon emissions in the atmosphere.  
(Correct answer: True)
- Levels of carbon in the atmosphere are approximately the same as they have been for thousands of years.  
(Correct answer: False)
- The current levels of carbon in the atmosphere have been recorded in the past during previous warming periods.  
(Correct answer: False)
- There is scientific consensus that there will be environmental impacts as a result of excess levels of carbon in the atmosphere.  
(Correct answer: True)



6. Carbon offsetting programs are available where consumers can invest in programs that absorb or reduce carbon in the atmosphere.  
(Correct answer: True)
7. A number of airlines and retail companies use carbon offsetting and/or make offsetting available to their customers.  
(Correct answer: True)
8. A single tree can absorb up to a ton of carbon from the atmosphere.  
(Correct answer: True)

## Study 2

Please indicate the correct answer(s).

Questions were adopted from: <https://www.energy.gov/articles/quiz-test-your-climate-change-iq>

1. How does the greenhouse effect work? (Correct answer: b)
  - a. Greenhouse gases reflect the sun's energy, causing it to warm the Earth.
  - b. Greenhouse gases absorb the sun's energy, slowing or preventing heat from escaping into space.
  - c. Greenhouse gases directly warm oceans and cause dramatic weather.
  - d. Oceans absorb greenhouse gases, which cause the Earth's temperature to rise.
  - e. I don't know
2. What is the most potent greenhouse gas? (Correct answer: a)
  - a. Fluorinated gases
  - b. Nitrous oxide
  - c. Carbon dioxide
  - d. Methane
  - e. I don't know
3. How much have global average temperatures increased in the last century? (Correct answer: d)
  - a. 2.1 degrees Fahrenheit
  - b. 0.6 degrees Fahrenheit
  - c. 4.3 degrees Fahrenheit
  - d. 1.4 degrees Fahrenheit
  - e. I don't know
4. How much have sea levels risen in the past 100 years? (Correct answer: a)
  - a. 7 inches
  - b. 2 inches
  - c. 5 inches
  - d. 16 inches
  - e. I don't know
5. How much have carbon dioxide emissions changed in the United States since 2006? (Correct answer: b)
  - a. Increased 560 million metric tons
  - b. Dropped 480 million metric tons
  - c. Increased 230 million metric tons
  - d. Dropped 120 million metric tons
  - e. I don't know
6. Which of these is considered a critical threshold for carbon dioxide levels in the atmosphere? (Correct answer: d)
  - a. 123 parts per million
  - b. 250 parts per million
  - c. 685 parts per million
  - d. 400 parts per million
  - e. I don't know
7. What is the biggest source of greenhouse gas emissions in the United States? (Correct answer: c)
  - a. Farming, logging and manufacturing
  - b. Heating and cooling buildings
  - c. Producing electricity
  - d. Using transportation
  - e. I don't know
8. What does carbon intensity measure? (Correct answer: a)
  - a. Carbon dioxide produced per dollar of gross domestic product

- b. Carbon dioxide produced per electrical charge
  - c. Carbon dioxide produced per kilowatt hour
  - d. Carbon dioxide produced per British thermal unit of energy
  - e. I don't know
9. During the 2015 United Nations Climate Change Conference in Paris, how many countries committed to doubling clean energy research and development? (Correct answer: c)
- a. 76
  - b. 195
  - c. 20
  - d. 12
  - e. I don't know